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July 1967 MASTER

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Westinghouse Astronuclear Laboratory

A Study of the Corrosion Resistance
of the "Grafoil" Wrapper System
(Title Unclassified)

1639

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WANL-TME-1639

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GROUP I

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MASTER

A Study of the Corrosion Resistance of the "Grafoil" Wrapper System
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by

R. J. Steffen
Thermo-Flow Laboratory

Classification cancelled (or ~~changed to~~ ______)
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by H. A. C.

Approved:

E A DeZubay

E. A. DeZubay, Manager
Thermo-Flow Laboratory

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CONFIDENTIAL R.D.

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ABSTRACT

(U) A test program designed to study the corrosion resistance of thermalized and non thermalized "Grafoil" in configurations simulating the NRX-A6 reactor core periphery geometry has been initiated.

(U) Preliminary designs and significant changes made to improve the quality of the data obtained are discussed along with new configurations, not all simulating reactor geometry, that are awaiting test.

(U) The data presented is in the form of tables and photographs which list parameters and resultant weight losses. Photographs show pre and post test conditions complete with scales that can be used to measure the amount of surface regression. The effects of flow rate, thermalization, and material temperature were investigated and the results presented.

(U) Tests were conducted at a pressure level of 350 psig for 30 minutes with material temperatures ranging from 3500 to 3700°R and hydrogen flow rates ranging from 4.27×10^{-5} to 8.58×10^{-5} lb/sec.

(C-RD) The configuration on which the data was gathered simulates an NbC coated filler strip gap 0.006 inches wide by 2 inches long by 0.280 inches deep in contact with a simulated "Grafoil" wrapper contained in a machined window 1 inch wide, 1.6 inches long and approximately 0.013 inches deep. Flow is along the filler strip gap exposing only a very small "Grafoil" area to hydrogen.

(U) This test series is an extension program of work previously presented

and the equipment used to test the specimens has not changed. However, the specimens have been modified to accomodate the "Grafoil" material coupon and are not now subject to corrosion, being NbC coated.

TABLE OF CONTENTS

INTRODUCTION

(U) Various methods have been investigated to reduce radial flow and cross communication between filler strip gaps on the periphery of the NRX core.

(C-RD) A solution for the above stated problems was to wrap the exterior of the core with "Grafoil" which, when properly held in place, would eliminate the troublesome flows and provide protection from heat loss by use of its low thermal conductivity. Mechanically, the material would function in that it is relatively easy to handle and pliable enough to match the radius of the item it was being molded to. Corrosion resistance of the material was an area that required close examination.

(U) The necessity for this information was sufficient justification for a test program which would test the "Grafoil" material in thermal environments and geometric configurations similar to the reactor. The results would provide designers with information that could be used to give confidence to present and future designs and also provide data for the calculations of corrosion rates which would improve accuracy of core life predictions.

(U) The test hardware performance was excellent and has the capability of providing large quantities of "Grafoil" corrosion data on a configuration that can be analyzed with relative ease and is not clouded by the complexities of large elaborate test rigs. Information of this nature can also be useful in understanding data from large test fixtures where the precise measurement and isolation of specific parameters is difficult.

(U) Several significant statements can be made regarding this test equipment, they are as follows:

1. There is no extranious hydrocarbon generation upstream of the test section.
2. The only exposed carbon in the system is the "Grafoil", the graphite foil holder is NbC coated, and the remainder of the fixturing is fabricated of pure molybdenum.
3. The test section is essentially isothermal.
4. The test system is capable of fine control of test parameters and can duplicate previously established conditions with the same accuracy.

These statements outline the unique features of this test fixturing which increase confidence levels in the data obtained.

EXPERIMENTAL EQUIPMENT

(U) The design, development, and operation of the test equipment is covered in detail in References 1 and 2. The above mentioned phases, plus the techniques of data gathering, have not changed since the publishing of Reference 2. This section will cover in detail the design and development phases of the "Grafoil" test specimen only.

(C-RD) The test fixture is a modification of a standard flow slot specimen and plug assembly designated as Items 226, 230, 234, and 238, Dwg. NT701486, sheet 2. The function of this specimen was to provide some similarity to the core periphery cross section, and include a portion of the "Grafoil" wrapper in contact with the filler strip gaps.

(C-RD) Initial designs made provision for 2 filler strip gaps of different depths on each side of the "Grafoil" wrapper which would be located on the center plane of the two specimen halves. Machining problems and flow rate determination difficulties made the multi filler strip gap fixture impractical and this type of design was abandoned. A fixture with a single filler strip gap was designed and was the type used throughout this program.

Ref. 1 Steffen, R. J., Test Series HHT-6, Preliminary Interelement Corrosion Study, (Title Unclassified), WANL-TME-1138, March 1965. CRD.

Ref. 2 Steffen, R. J., Test Series HHT-6, Experimental Investigation of Interstitial Corrosion For An Isothermal Model Phase I, (Title Unclassified), WANL-TME-1430, May 1966. CRD.

(U) Three different machining operations were tested to obtain a satisfactory filler gap. The criteria for the gap was that it must be as narrow and as deep as possible, 0.006 inches in width and 0.250 inches in depth being the upper limits. Attempts to machine this gap by the Elox and circular saw method were not successful. A satisfactory filler gap was obtained by surface grinding a cutting tool to the proper configuration and then using a shaper to cut the flow slot. Widths of less than 0.006 inches and depths in the range of 0.280 to 0.290 inches could be consistently obtained before tool failure.

(U) The opposite half of the specimen contains a window which holds the "Grafoil" coupon. The coupon is 1.6 inches long and one inch in width and its size is matched as closely as possible to the limits of the window. The depth of the window is regulated so that there is 0 to 0.0005 inches of compressive fit between the "Grafoil" and the opposite specimen half when the hot condition is reached. The coefficient of expansion in the "A" direction is such that the window grows away from the foil. This condition produces gaps on all edges in excess of 0.002 inches at temperature and requires that the cold fit be very accurate so these separations are held to a minimum. The window also has a plenum 1 inch wide by 0.1 inches long by 0.010 inches deep at the exhaust end to simulate the end of the filler strip and expose the edge of the "Grafoil" to hydrogen. The new flow slot orientation required a change in molybdenum plug design and called for the plugs to be rotated 90° to the center plane of the specimen halves which made a relocation of the alignment pins necessary.

(U) Figure 1 shows an exploded view of the test specimen with "Grafoil" coupon, molybdenum plugs and tapered retaining ring. Note that the true position of the molybdenum plugs is 90° to the position shown relative to the specimen halves.

(U) Figure 2 shows a fixture that has been NbC coated. The flow slot, "Grafoil" window and thermocouple holes being clearly visible.

(U) Before each test, the specimen is carefully documented as to the size of flow gap, "Grafoil" window and "Grafoil" coupon. Weights of every component are determined and recorded on the dimension data sheet. The pre test surface condition and the coupon fit in the window is recorded photographically so there is a basis of comparison on which corrosion can be assessed after the test is conducted. At the conclusion of the test, the same information is gathered, the weight loss being obtained first followed by photos and dimensional checks respectively.

(U) These tests were conducted at an inlet pressure of 350 psig for a time limit of 30 minutes under hydrogen at temperature. Hydrogen flows of 4.27×10^{-5} and 8.58×10^{-5} lb/sec. were used in conjunction with material temperatures of 3500 and 3700°R, in both cases the former temperature is the maximum nominal average and the latter temperature is the maximum nominal maximum, in order to observe the effects of flow rate and material temperature.

(U) A change in the measurement of material temperature was made in that the number of thermocouples could be reduced to one which measures the temperature of the specimen's mid plane. The second thermocouple has been replaced by an optical pyrometer which is sighted on the aft end of the specimen. The pyrometer has been calibrated to the thermocouple and can be used to control the temperature in the event of thermocouple failure once the switch to hydrogen is made. The response time of the pyrometer is too low to effectively pick up the changes in temperature created by the switch to hydrogen.

(U) This new system reduces the number of thermocouples required to conduct the test program and provides a good check of material temperature levels in the event a faulty thermocouple is encountered. The pyrometer can be used alone in tests where very precise control, using the temperature measurement is not required.

(U) The most important bits of information obtained from this test are those of weight loss and the pre and post test photos. This data is sufficient to make an assessment of the corrosion and determine if the material is capable of performing the required task in the reactor, also it provides the most direct method to determine what the effects of mass flow, material temperature, and thermalization are on overall corrosion resistance of the "Grafoil" material. Initial measurements must also be provided if corrosion rates are to be calculated.

(U) An error analysis performed on the values of temperature, pressure, flow rate, test time, reaction area, and weight loss has produced the following results.

Parameter	Maximum Cumulative Error %
Temperature	± 1.007%
Pressure	± .45%
Flow Rate	± 2.2%
Test Time	± .61%

(U) The measurement of reaction area on the "Grafoil" coupon is directly dependent upon the skill and training of the individual taking the measurements, which makes a quoted accuracy figure non realistic. Measurements of weights are made on a balance accurate to ± .001 gms.

RESULTS

(U) Two tests were conducted to prove the fixture design and establish operational limitations. These tests also provided learning curve information for operators and individuals responsible for the assembly and disassembly of the test specimens, and was also valuable in the development of techniques used to record and transmit data.

(U) The non thermalized "Grafoil" material used in these tests was purchased from High Temperature Materials Inc., and is identified as grafoil, Type 100, 12 inches wide x 0.010 inches thick x 20 feet long. The thermalized material carries the same nomenclature but was purchased in one inch wide x 0.010 inches thick x 1000 feet long tape in the non thermalized condition. The thermalization process was carried out in the WANL Materials Laboratory and conformed to the following schedule, 2200°C in an Argon atmosphere furnace for 30 minutes with a normal furnace cool.

(C-RD) The first test contained a 0.010 inch thick non thermalized "Grafoil" coupon in contact with a non coated filler gap and window. The standard 4.3×10^{-5} lb/sec. hydrogen flow was used with a material temperature of 4000°R. This test was to be conducted for 60 minutes but was concluded at the 30 minute mark due to unstable temperature readings. Disassembly of the fixture showed the high temperature level to be quite severe on the hardware in that the carbided outer surfaces of the molybdenum can be melted. The coupon showed slight corrosion in the form of a black line on the surface exposed to the filler gap. Measurement data indicated that the non thermalized "Grafoil" swelled 1.5 mils which would tend to separate the fixture halves making the aft end seal ineffective and reducing the hydrogen flow through the filler slot.

(C-RD) Based on these results, it was recommended that the material temperature be reduced to 3500°R and the test time reduced to 30 minutes. The second test was conducted with these changes and used thermalized material which became of interest. The results showed more corrosion on the "Grafoil" because hydrogen was directed to the proper areas. Figure 3 shows the disassembled specimen with the coupon positioned in the window. The photo clearly shows the corrosion on the inlet of the filler gap and on the "Grafoil" opposite the flow slot. Damage to the outer edges of the specimen is also noticeable indicating again that the aft end seal became ineffective after an unknown number of minutes.

(C-RD) Figure 4 is a composite of photomacrographs taken of various areas of interest on this specimen, it shows the inlet area of the "Grafoil" in both planes and the inlet corrosion profile of the filler gap. Also provided is a scale which will aid the reader in determining the exact amount of material removal.

(C-RD) These photos show extensive damage to the graphite specimen in the filler gap, around the outer edges, and at the entrance to the "Grafoil" window. To simulate reactor conditions the holder was coated with NbC on the exposed half faces and in the filler gap. This coating helps to prevent generation of hydrocarbons due to corrosion of the graphite and provides a more realistic picture of what will happen in the core. Figure 2 shows a typical specimen after the coating operation.

(U) After the improvements, sighted by the first two tests were incorporated in the program, a test series was started. This series was designed to determine the general corrosion resistance of the "Grafoil" material and the effects of thermalization, mass flow rate, and material temperature.

(U) Table 1 shows the test conditions and results of this test series tabulated in chronological order. The first test is designated by No. TFL-5.b-031, it is a test conducted at normal conditions, (30 min., 350 psig, 3500°R, and 4.3×10^{-5} lb/sec. H_2), with a coupon of 0.010 inches thick thermalized "Grafoil".

(U) Figure 5 shows the specimen after test with the coupon in the window. Corrosion on the "Grafoil" opposite the filler gap and on the edges is visible. Figure 6 is a close up of the coupon in the window with a scale for measurement of surface regression and through hole diameters. The next three (3) tests designated by No. TFL-5.b-032, 033, and 035 were all conducted at normal test conditions with coupons of 0.010 inch thick non thermalized "Grafoil". Figures 7, 8, and 9 show the typical before and after condition of the 3 non thermalized "Grafoil" tests. Figures 7 and 9 provide an excellent basis on which to judge the corrosion damage.

(U) Test TFL-5.b-036 was conducted at the normal conditions of pressure, time, and temperature with the flow rate increased by a factor of two. Figures

10, 11, and 12 show the before and after condition of this particular specimen.

(C-RD) Test TFL-5.b-037 was conducted at the normal conditions of pressure, time, and flow rate with the average material temperature 200 degrees hotter than the normal 3500°R. The corrosion pattern observed was typical of those previously obtained but a higher degree of surface regression can be seen by inspection of Figures 13, 14, and 15.

(C-RD) The measured weight loss of the first four "Grafoil" specimens does not give a direct indication that the corrosion resistance of the thermalized "Grafoil" is greater than that of non thermalized "Grafoil". Insufficient data was obtained to determine that the order of magnitude between resistance values may not be a direct function of weight loss due to the fact that the non thermalized material experiences a weight loss due to outgassing or thermalization during the test. It is questionable whether this weight loss can be considered hydrogen corrosion. Another factor contributing to this weight difference is the minimum amount of corrosion noticed on the edges of the thermalized coupon (Figure 6). The axial edges of the coupon were factory prepared and required no trimming to fit the window, the edges of the non thermalized coupons were all prepared in the laboratory. Examination of both types of edges show that the lamina on the thermalized factory prepared edge were more tightly compacted and sealed than those on the non thermalized laboratory cut coupon. This type of physical difference can contribute to the apparent superior corrosion resistance of the thermalized material.

(C-RD) Test TFL-5.b-036 conducted at the high flow rate had a resultant weight loss 13.9% above the average loss observed for tests TFL-5.b-032, 033, and 035, which indicates that at these conditions the reaction is relatively insensitive to increases in flow rate. A pure surface controlled reaction would be insensitive to flow rate.

(C-RD) Test TFL-5.b-037 conducted at the high temperature level had a resultant weight loss 62.5% greater than the average loss observed for tests TFL-5.b-032, 033, and 035. These results indicate that material temperature is a very strong variable in the corrosion reaction and gives an expected order of magnitude increase in corrosion with increased temperature. This specimen contained the first coupon that had corrosion completely through the "Grafoil" that developed into damage greater than small local holes. Initial "Grafoil" thicknesses and test conditions provide information on wrapper thicknesses that are necessary to prevent radial in flow for the duration of the reactor test.

CONCLUSIONS

(U) A test series has been conducted that provides "Grafoil" corrosion resistance information and also indicates the change in corrosion damage that can be expected with the use of thermalized material, increases in mass flow, and material temperature.

(C-RD) These results were valuable in the prediction of core periphery lifetime and influenced the design of the "Grafoil" wrapper configuration.

(C-RD) The results also show that material temperature is a much stronger function to consider than mass flow, due to the relative increases in corrosion damage with increase in both parameters.

(U) It should be noted also that direct comparison between these results and expected reactor performance can not be made until the pressure level is compensated for. Information on the effects of pressure increase on the corrosion rate of Graphitite "G" are presented in Reference 3 and provide the reader with an idea of rate increases with pressure.

Ref. 3 Steffen, R. J., Test Series TFL-5.b, Experimental Investigation of Interstitial Corrosion For An Isothermal Model Phase II, (Title Unclassified), January 1967. WANL-TME-1562. CRD.

RECOMMENDATIONS

(U) Based on the experience gained in the behavior of this material and the desire for more information, it is recommended that the following steps be taken to further improve the quality and quantity of the data obtained.

1. Conduct tests to determine the effect of pressure on the corrosion rate of this material.
2. Obtain more data on the corrosion characteristics at various temperatures.
3. Conduct tests to determine the effect of flow geometry change on corrosion rate. Fixtures are available that provide multi layer and extra wide flow slot configurations.
4. Expand the scope of material candidates to laminates produced by different processes such as hot pressed and adhesive bonded in an effort to locate a more favorable material.
5. Investigate more effective ways of measuring material removal such as a positive displacement method.
6. Investigate the possibilities of a pure molybdenum "Grafoil" holder which could be reusable and would eliminate the necessity of continual machining and NbC coating operations.

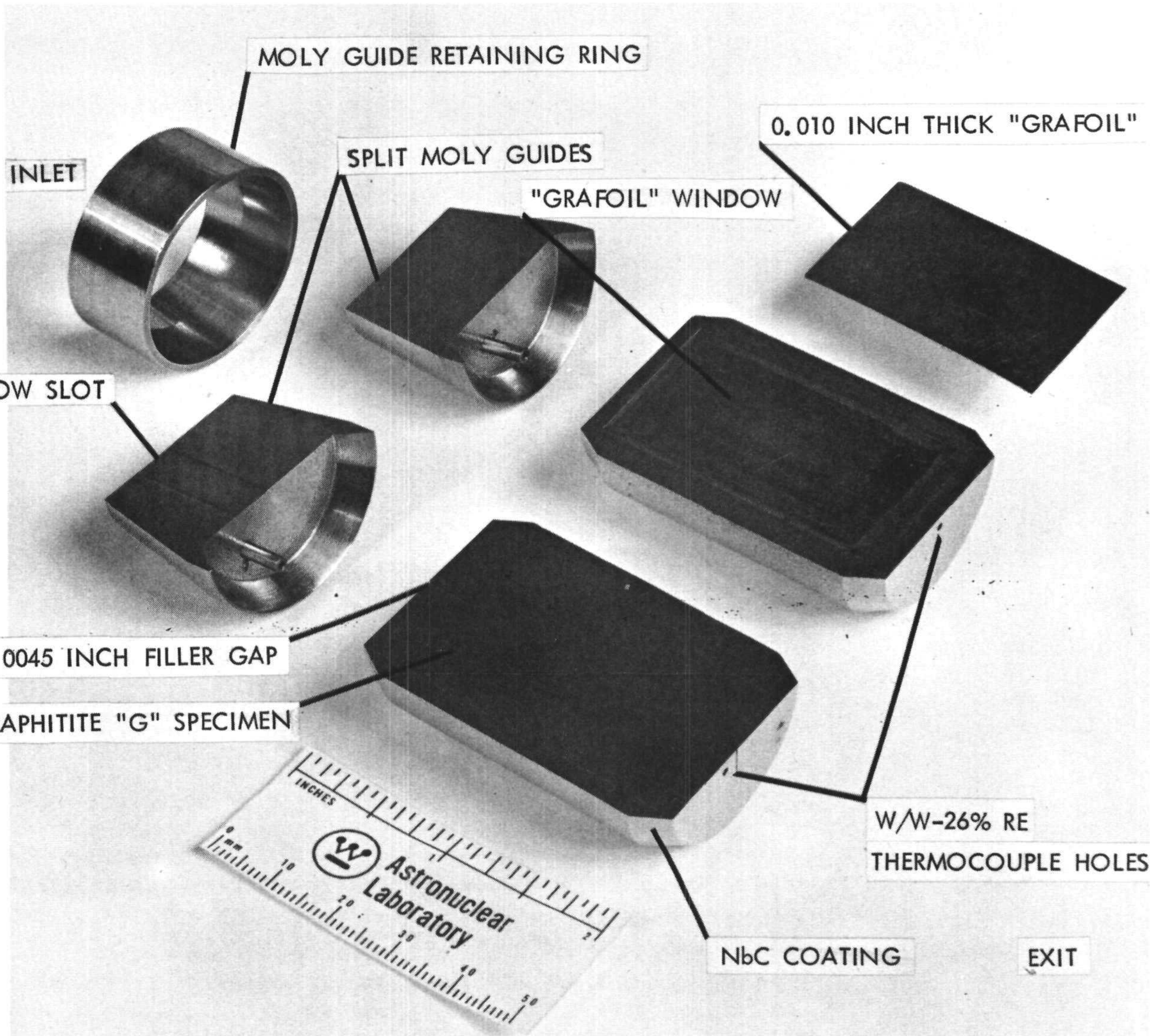

Figure 1

Pyrofoil Corrosion Test Hardware

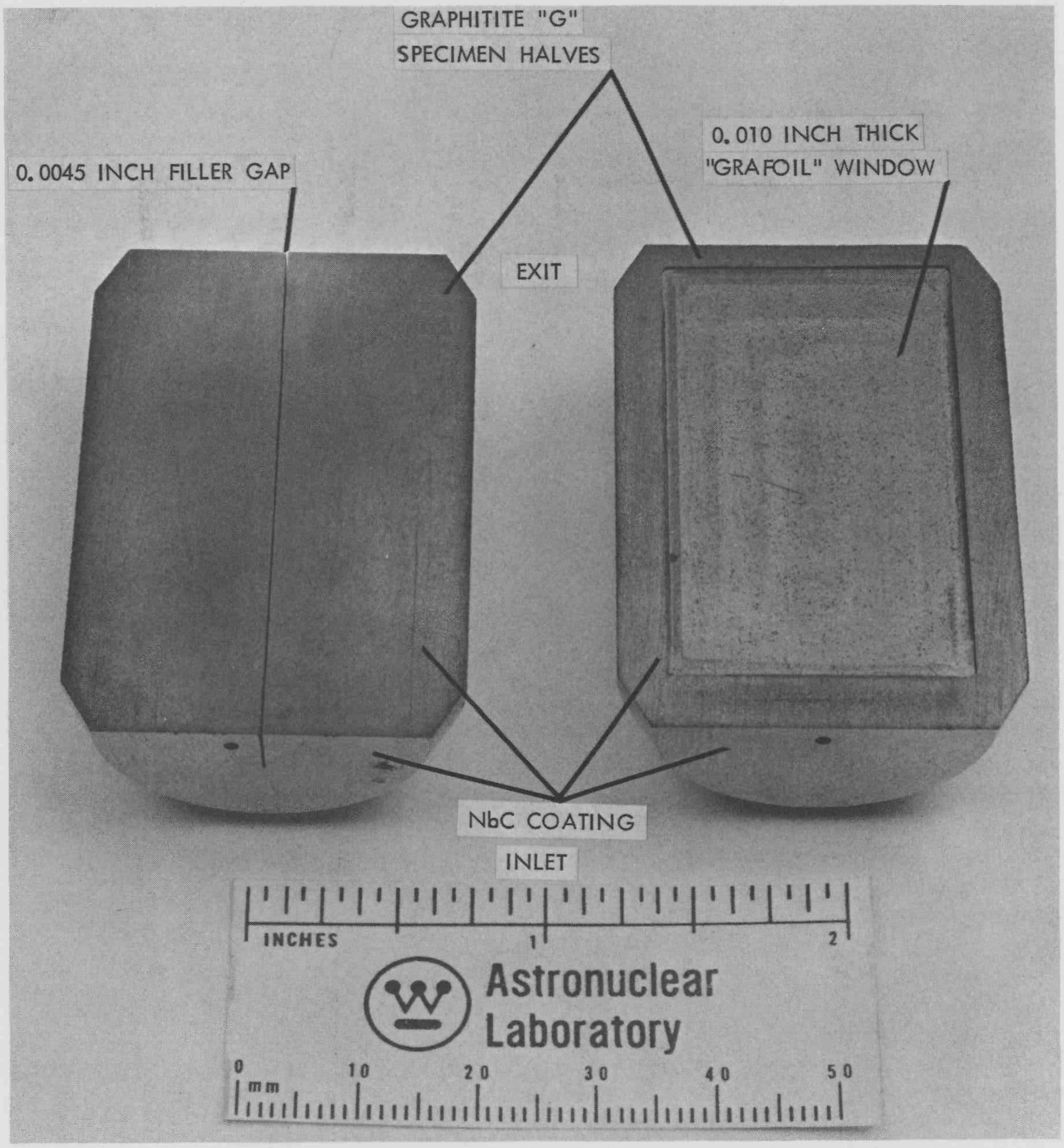

Figure 2

Pyrofoil Corrosion Test Hardware

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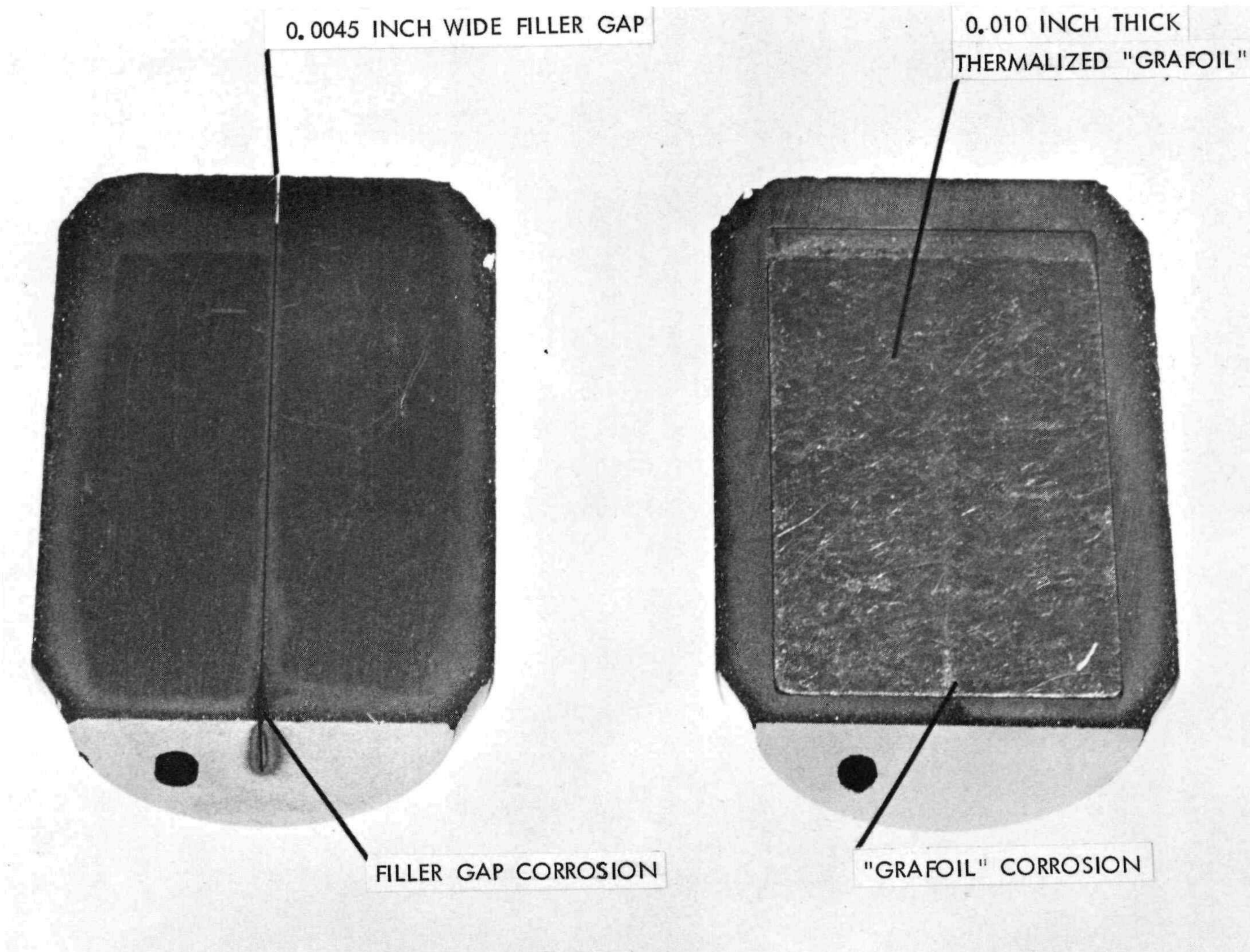

INLET

Figure 3

Second Pyrofoil Test, 3500°R, 30 Minutes

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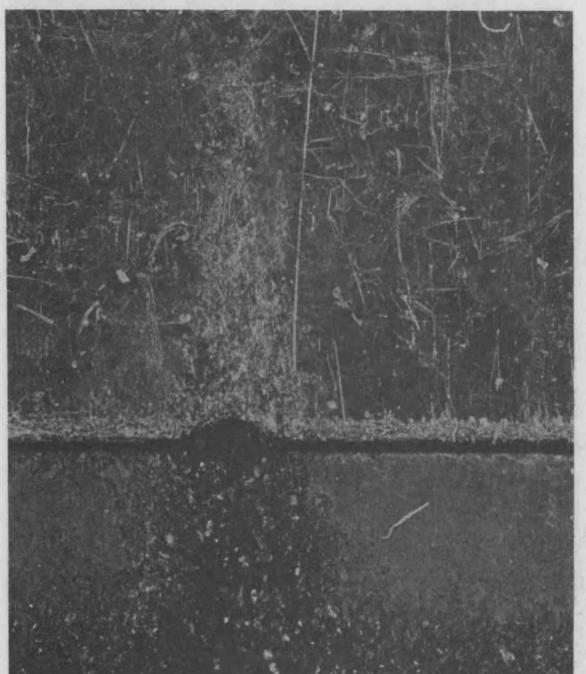
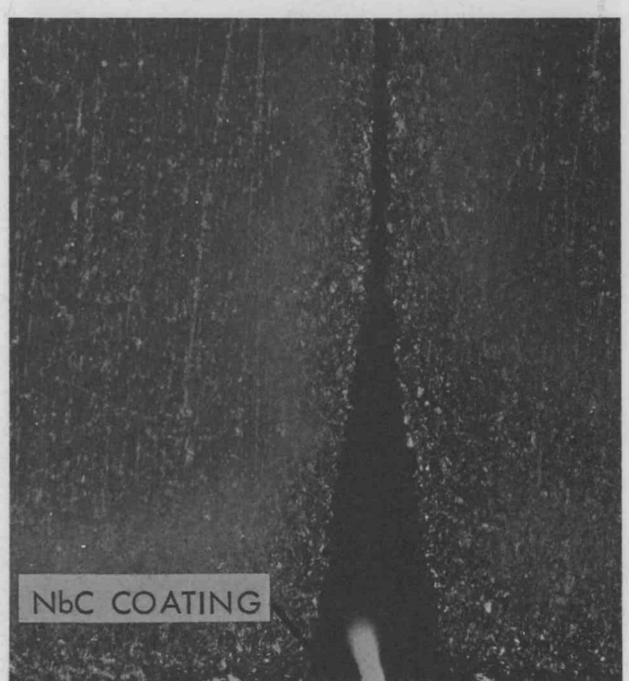
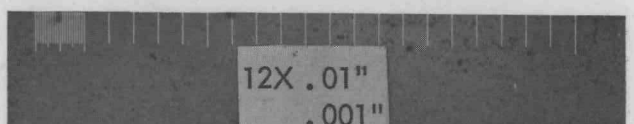


12X PHOTO OF "GRAFOIL" INLET



12X PHOTO OF CORROSION ON INLET OF FILLER GAP

INLET EDGE OF PYROFOIL AT 12X SECOND TEST



SCALE USED TO MEASURE PHOTOMACROGRAPHS
LARGE DIVISION .01 INCH SMALL DIVISION .001 INCH

Figure 4

Photomacrographs of the Second "Grafoil" Test

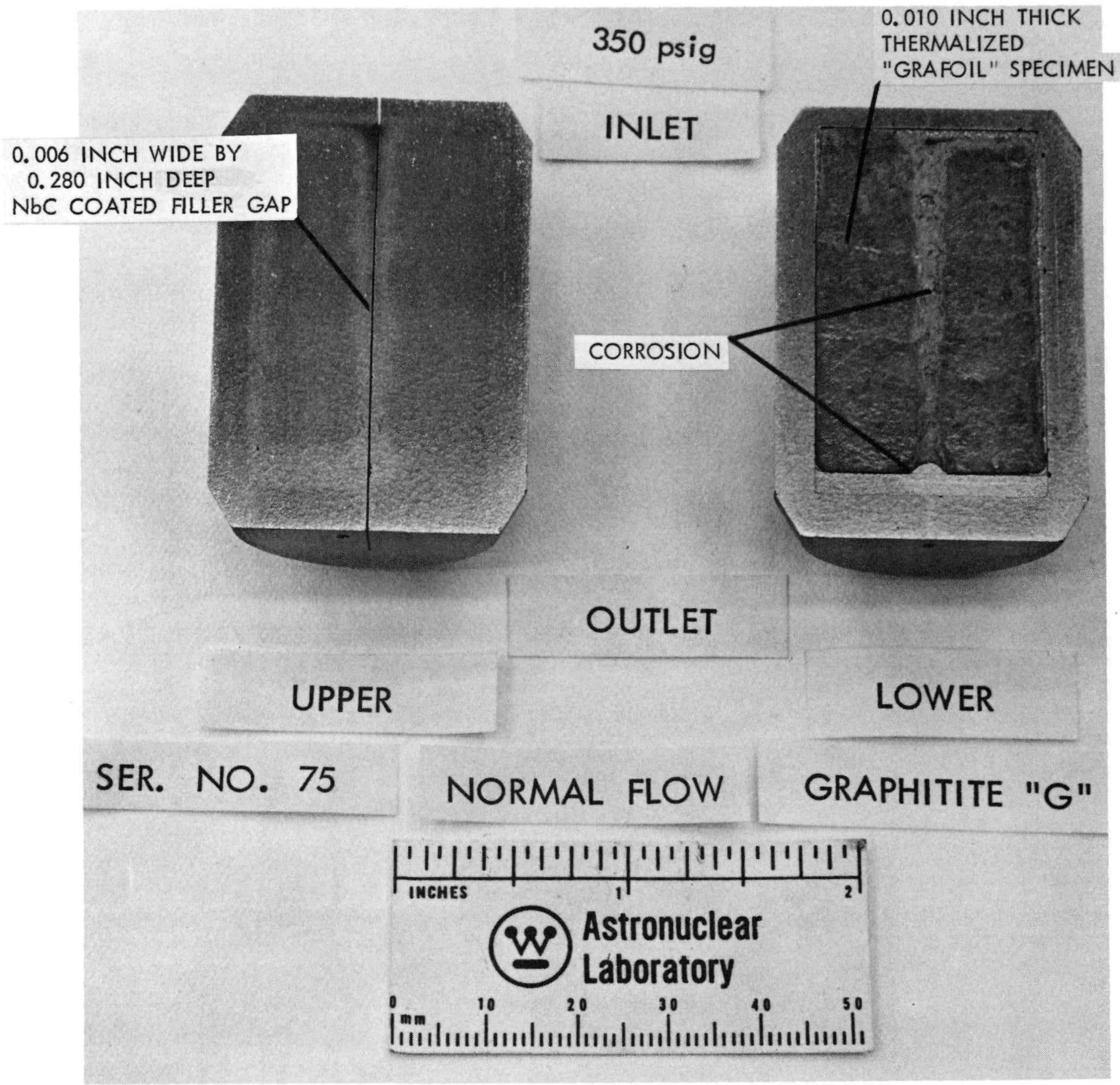


Figure 5

Thermalized "Grafoil" Specimen in Fixture After Test No. TFL-5.b-031

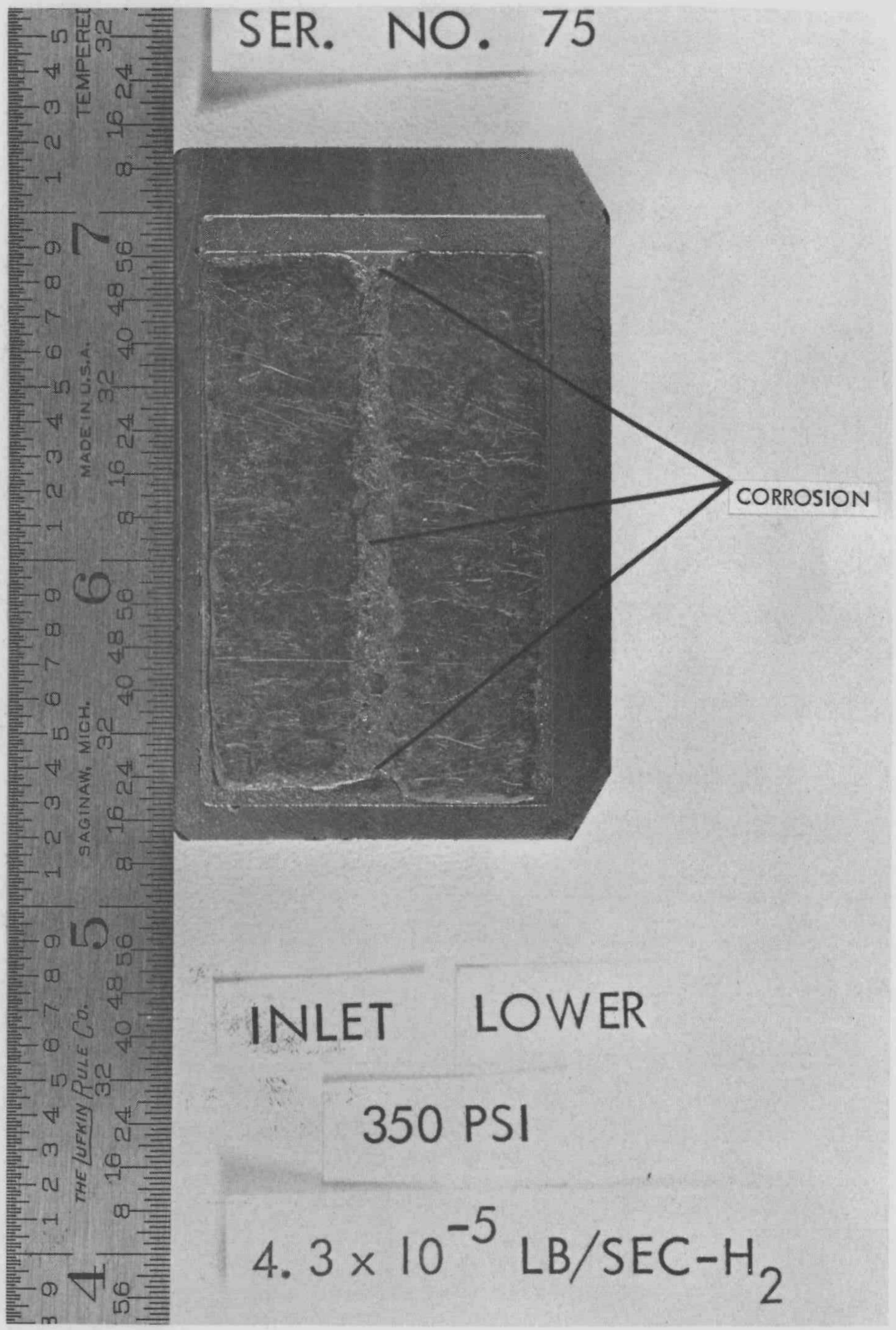


Figure 6

Enlarged 0.010 Inch Thick Thermalized "Grafoil" Specimen in Fixture After Test No. TFL-5.b-031

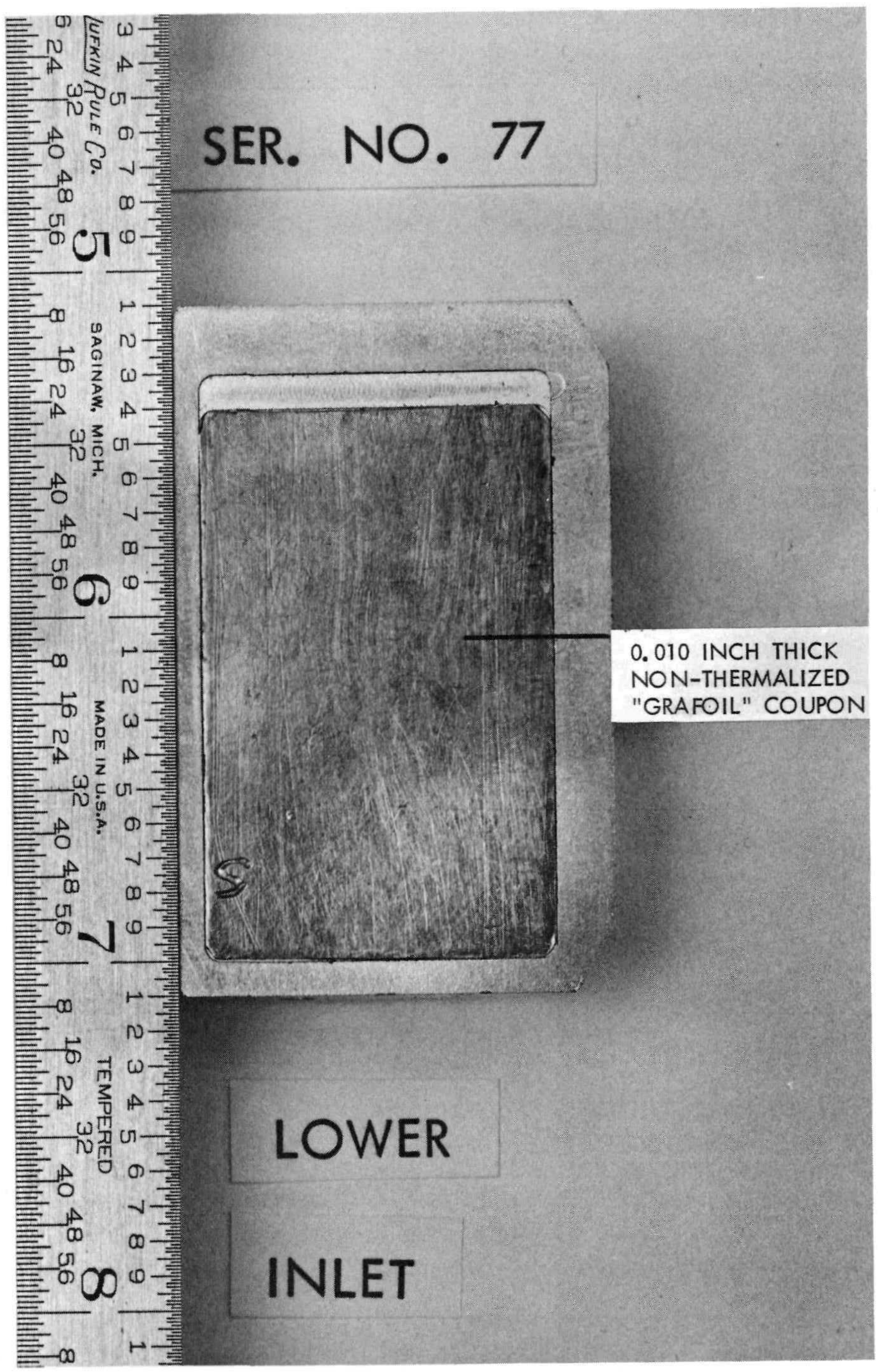


Figure 7

Coupon in Window Before Test No. TFL-5.b-035

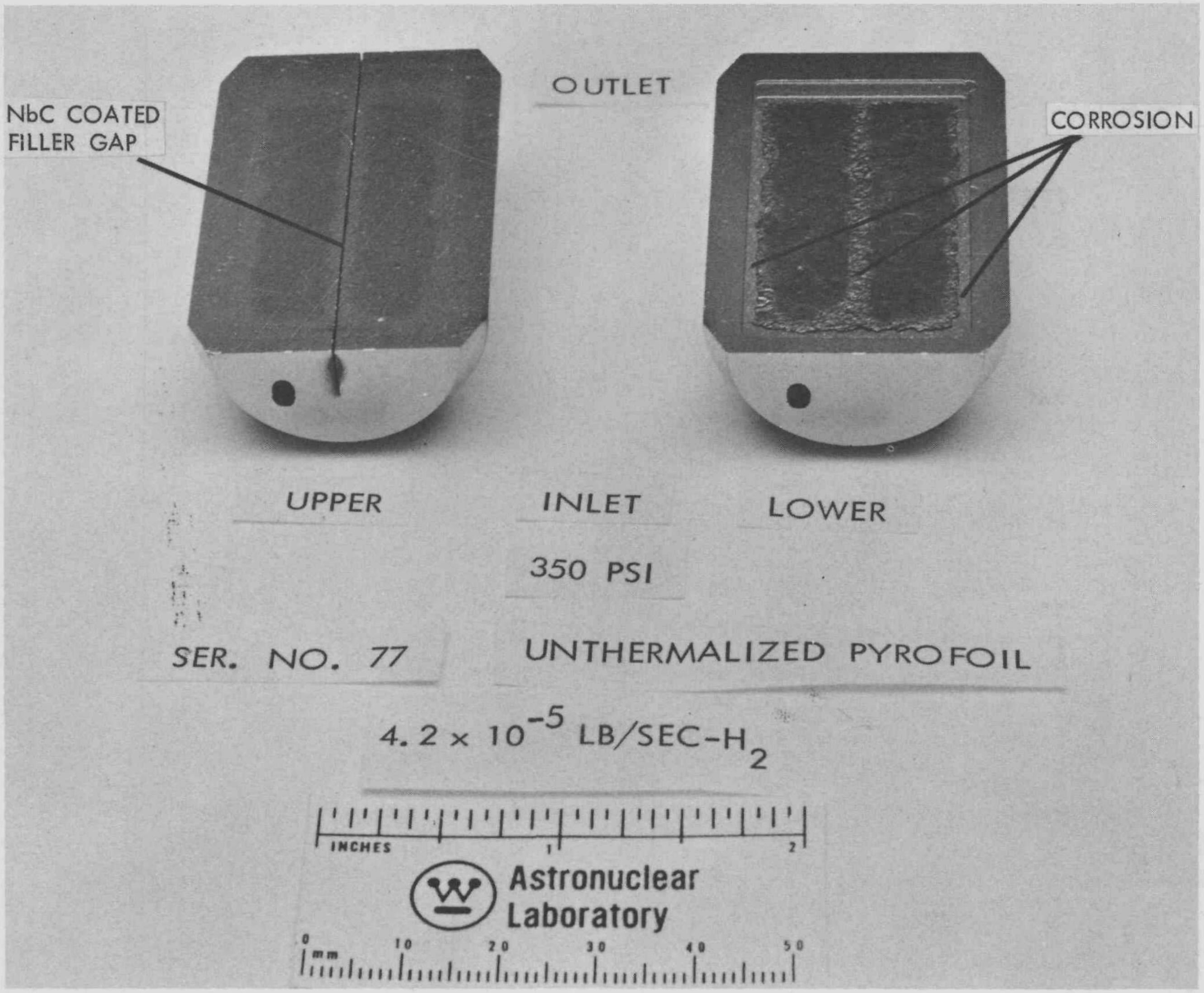


Figure 8

Test Specimen and Coupon After Test No. TFL-5.b-035

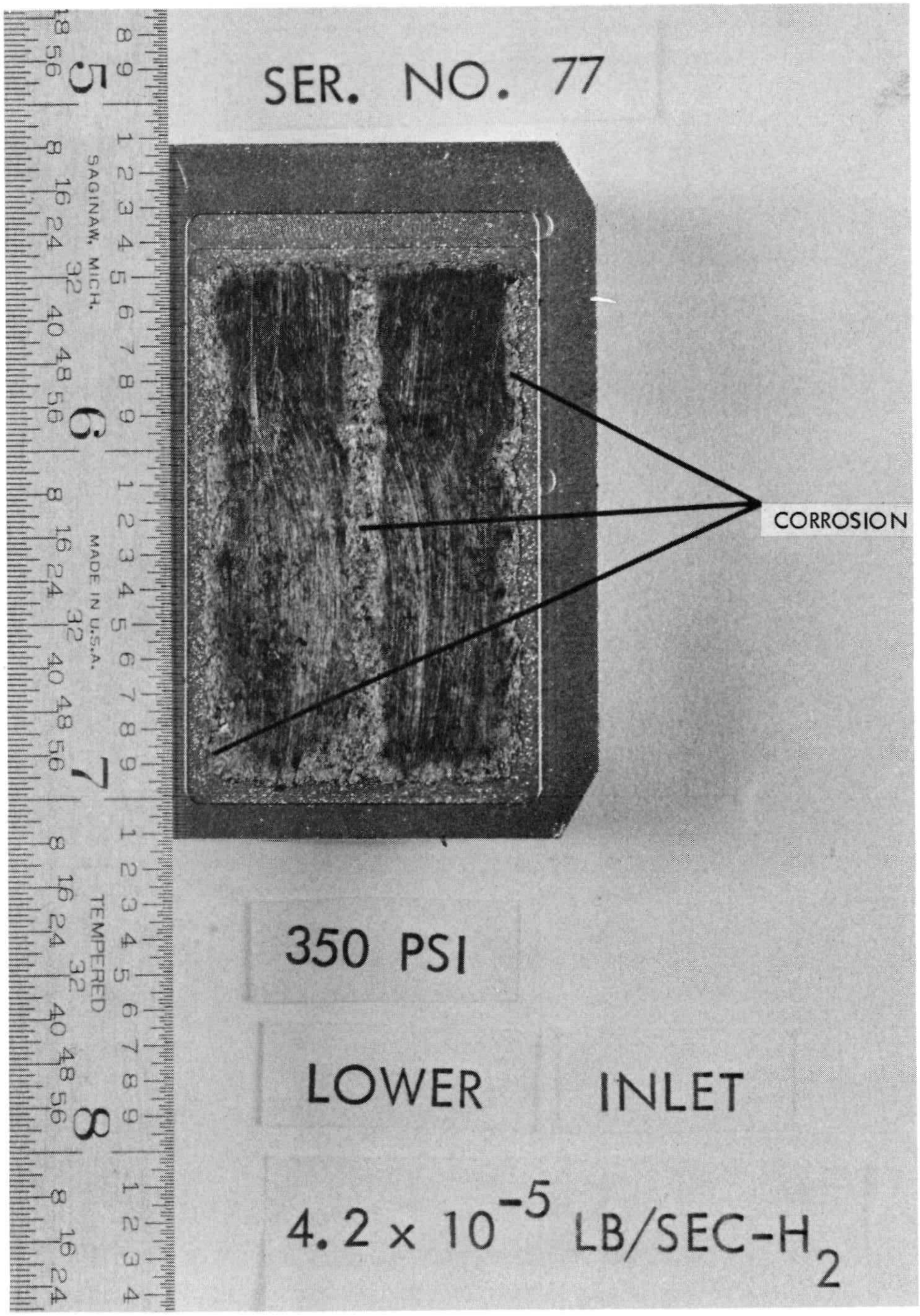


Figure 9

Close Up of Coupon After Test No. TFL-5.b-035

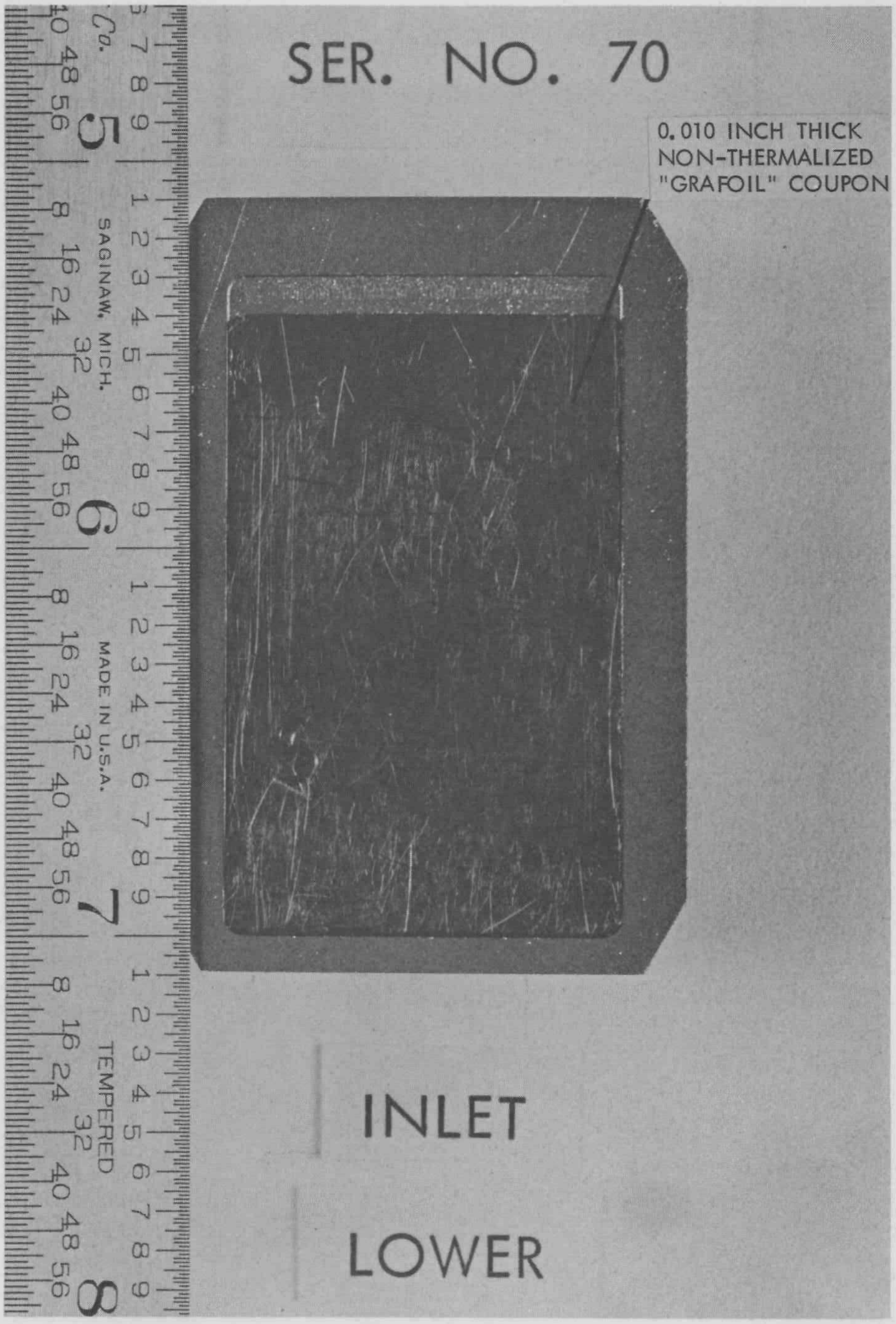


Figure 10

Close Up of Coupon in Specimen Before Test No. TFL-5.b-036

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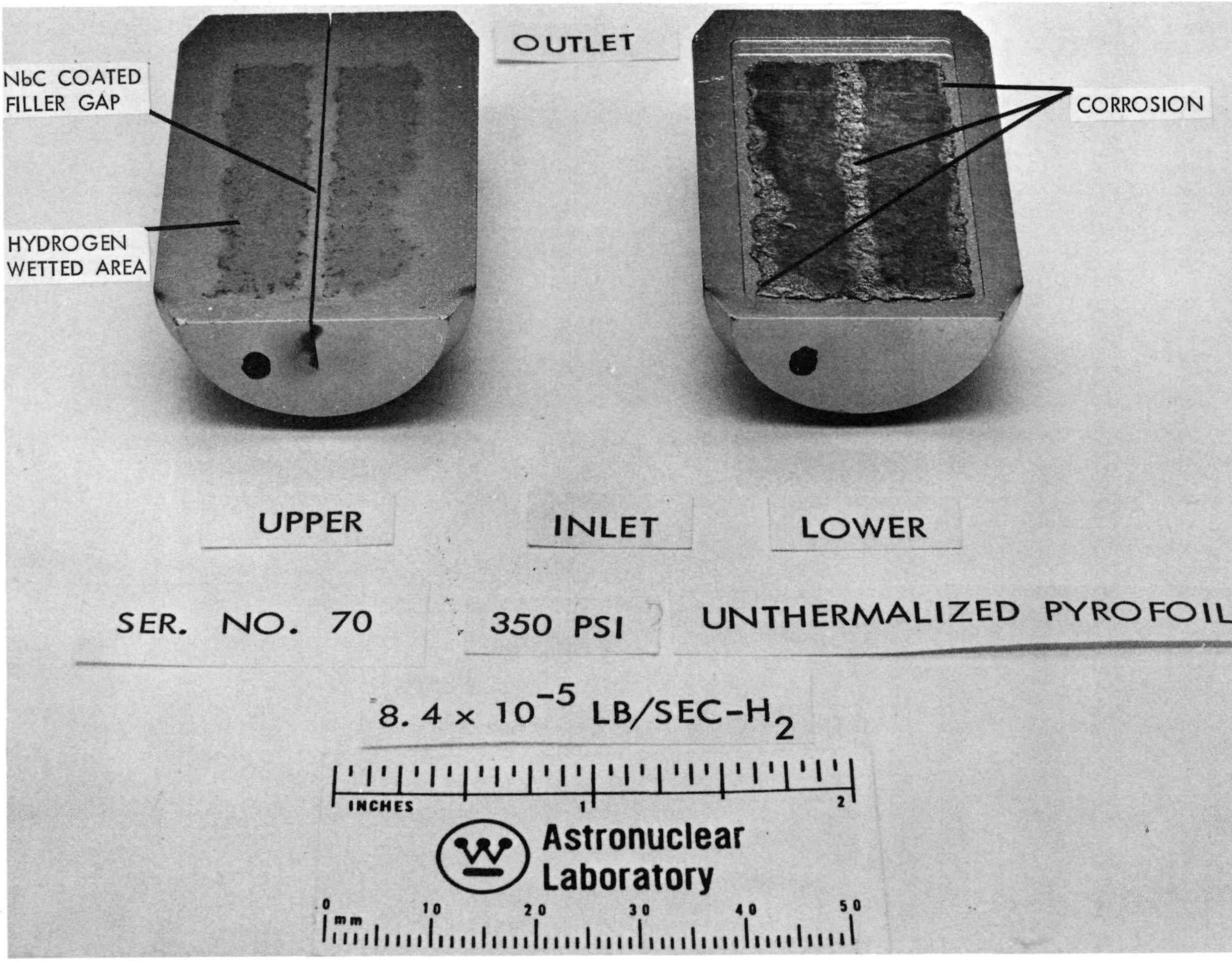

Figure 11

Opened Test Fixture After Test No. TFL-5.b-036

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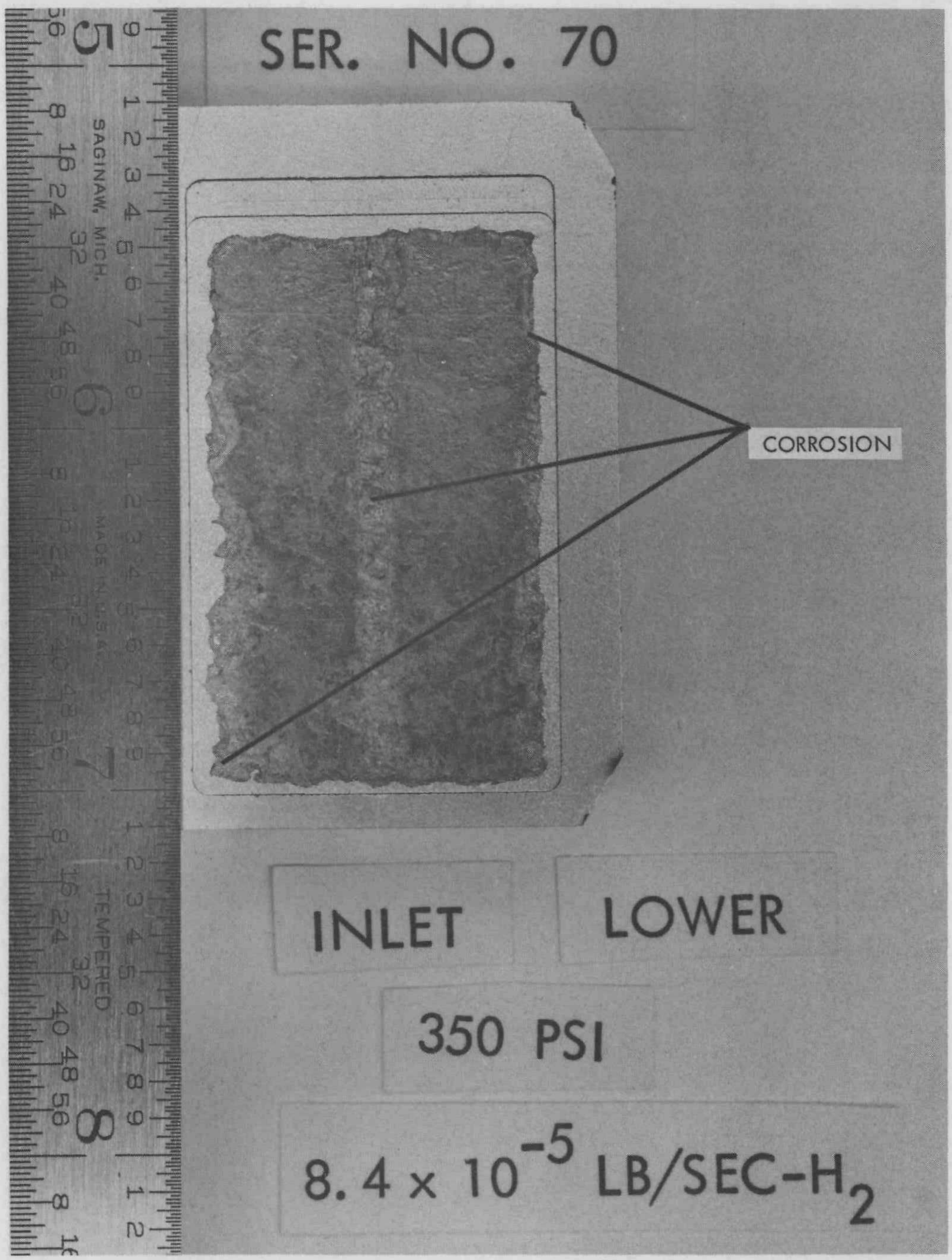

Figure 12

Close Up of Coupon in Fixture After Test No. TFL-5.b-036

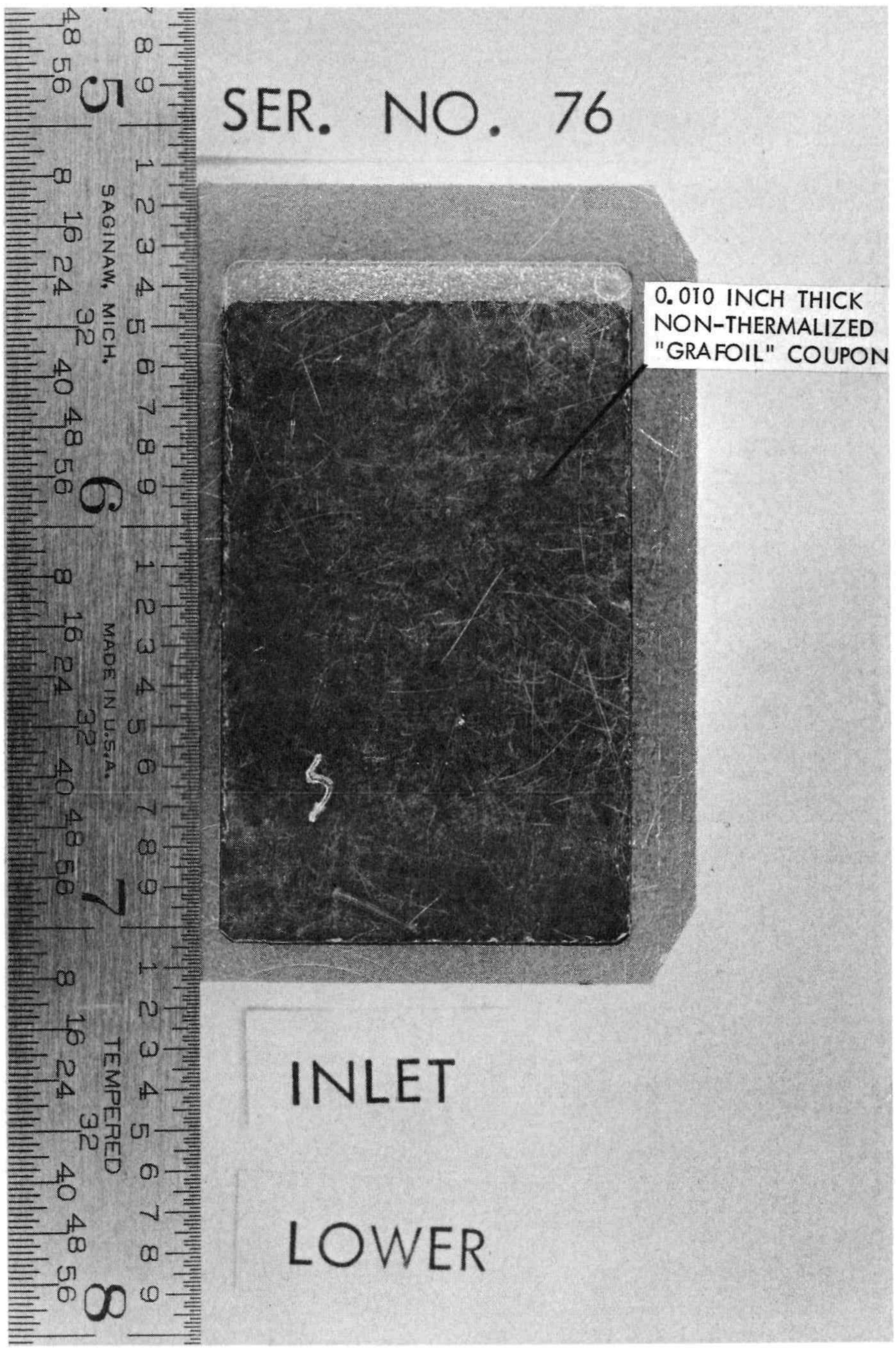

Figure 13

Close Up of Coupon in Fixture Before Test TFL-5.b-037

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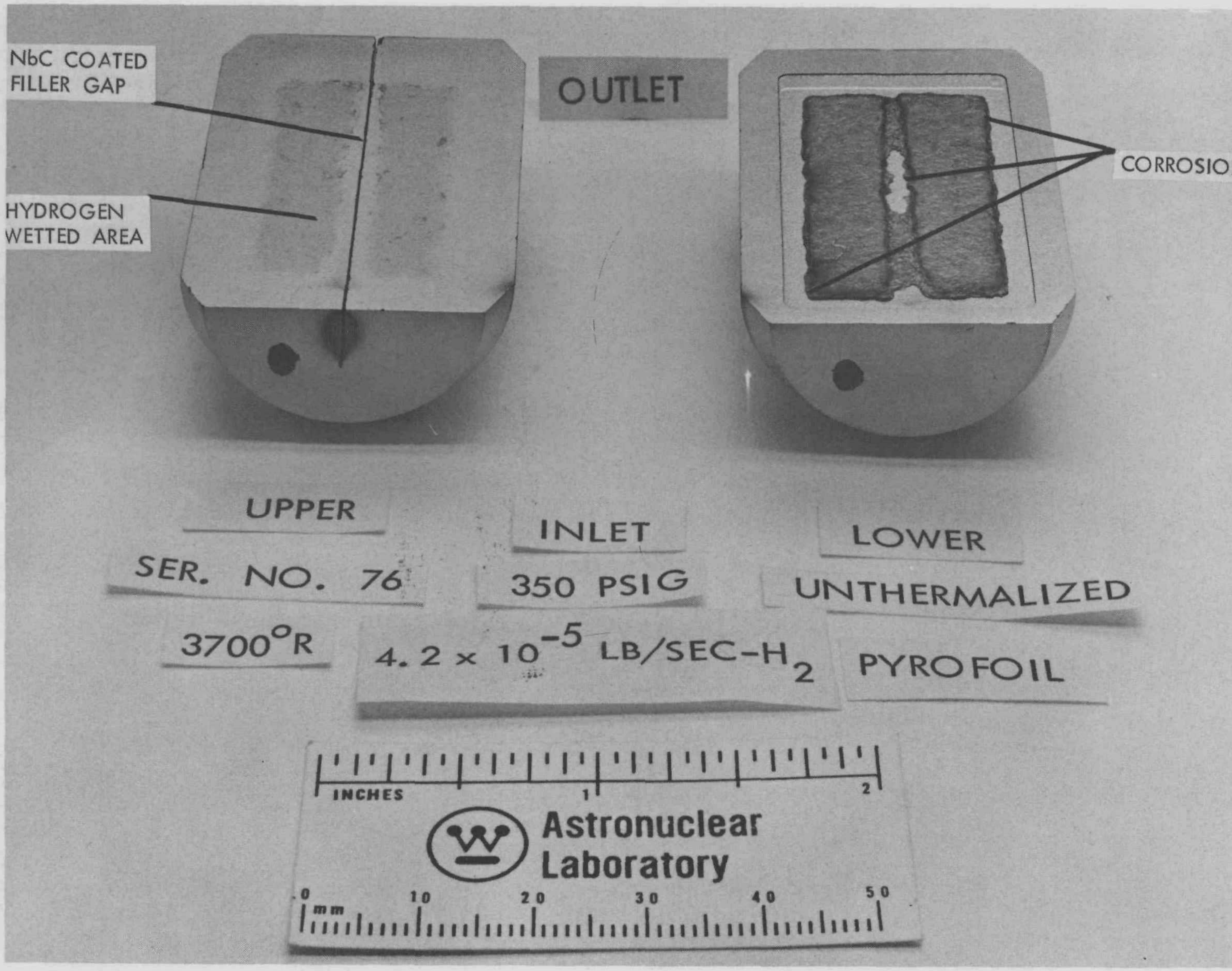

Figure 14

Test Fixture Layout After Test No. TFL-5.b-037

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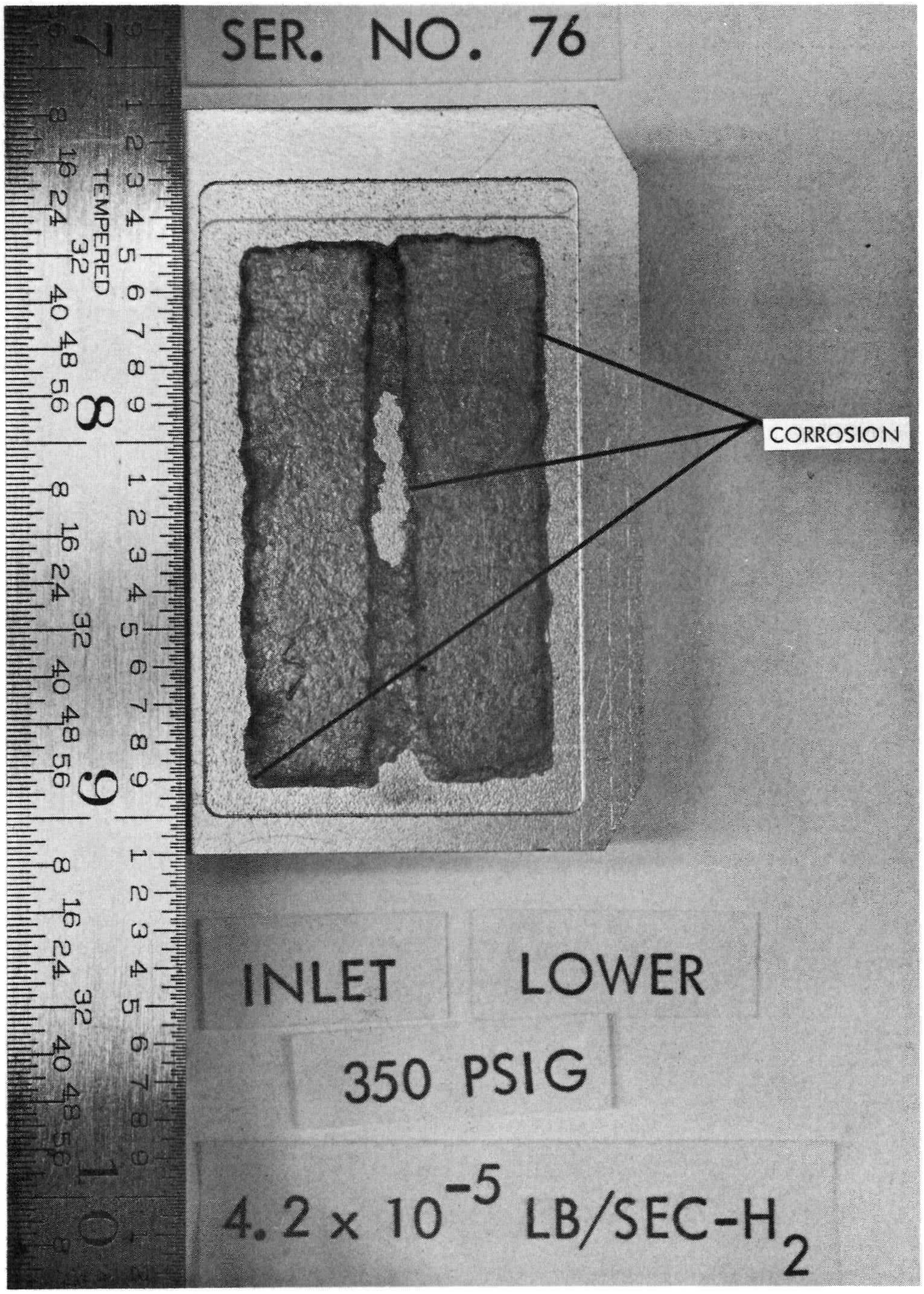

Figure 15

Close Up of Coupon in Fixture After Test No. TFL-5.b-037

TABLE I

"GRAFOIL" CORROSION TEST TABULATION SHEET

Build Description	Test No.	Run Time	Inlet Pressure	Inlet Gas Temp.	Outlet Gas Temp.	Inlet Mtl. Temp.	Outlet Mtl. Temp.	Ave. Mtl. Temp.	Flow Rate	Specimen Wt. Loss	"Grafoil" Wt. Loss
	TFL-5.b	Min.	psig	°R	°R	°R	°R	°R	lb/sec H_2	gms.	gms.
Serial No. 75 Coated Slot .010 inch thick thermalized	031	30	350	525	1626	3498	3492	3495	4.3×10^{-5}	.073	.0405
Serial No. 74 Coated Slot .010 inch thick non thermalized	032	30	350	524	2151	NG	3501	-	4.27×10^{-5}	.080	.077
Serial No. 73 Coated Slot .010 inch thick non thermalized	033	30	350	526	1951	3476	3518	3497	4.27×10^{-5}	.080	.061
Serial No. 77 Coated Slot .010 inch thick non thermalized	035	30	350	520	NG	3484	3508	3496	4.27×10^{-5}	.136	.078
Serial No. 70 Coated Slot .010 inch thick non thermalized	036	30	350	518	2460+	3465	3534	3499	8.58×10^{-5}	.110	.082
Serial No. 76 Coated Slot .010 inch thick non thermalized	037	30	350	520	2136	-	-	3697	4.28×10^{-5}	.132	.117

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APPENDIX A

(U) Appendix A is composed of pre and post test measurement data covering all the tests reported. The information presented applies to the "Grafoil" coupon only and is listed in order of test.

(U) Figure 16 shows the location of the pre and post test measurements. Post test measurements are designated by letter combinations in some cases due to absence of material and corrosion patterns. These letter combinations indicate that the reading was taken between the two letter locations.

(U) Thickness measurements were taken with a flat head micrometer and represent maximum thicknesses of areas not directly exposed to hydrogen.

(U) Width and length measurements were taken with a scale graduated in 0.01 inches and a high power glass, a vernier caliper was first tried but was cumbersome and damaged the coupon.

(U) The pre and post test weights give a relative order of magnitude of the "Grafoil" coupon weight loss and allow the reader to express the weight loss in percent if so desired.

A	B	C
D	E	F
G	H	I
J	K	L
M	N	O
P	Q	R

Location of Measurement Points on "Grafoil" Coupon

Figure 16

PRE TEST

Weight 0.293 gms.

Thickness		Width		Length	
A	.0122	A-C	.993	A-P	1.596
B	.0124	D-F	.992	B-Q	1.595
C	.0118	G-I	.993	C-R	1.590
D	.0122	J-L	.992		
E	.0122	M-O	.993		
F	.0120	P-R	.993		
G	.0121				
H	.0121				
I	.0122				
J	.0119				
K	.0120				
L	.0120				
M	.0121				
N	.0118				
O	.0119				
P	.0120				
Q	.0120				
R	.0119				

POST TEST

Weight 0.2525 gms.

Thickness		Width		Length	
A-B	.0120	A-C	.918	A-P	1.590
B-C	.0118	D-F	.942	B-Q	1.462
D-E	.0119	G-I	.950	C-R	1.550
E-F	.0119	J-L	.954		
G-H	.0122	M-O	.960		
H-I	.0119	P-R	.964		
J-K	.0121				
K-L	.0121				
M-N	.0120				
N-O	.0119				
P-Q	.0120				
Q-R	.0119				

Measurements of Coupon Ser. No. 75, Test No. TFL-5.b-031

PRE TEST

Weight 0.305 gms.

Thickness		Width		Length	
A	.0104	A-C	.997	A-P	1.597
B	.0103	D-F	.997	B-Q	1.595
C	.0104	G-I	.996	C-R	1.595
D	.0104	J-L	.996		
E	.0104	M-O	.996		
F	.0104	P-R	.996		
G	.0103				
H	.0104				
I	.0104				
J	.0104				
K	.0103				
L	.0103				
M	.0104				
N	.0103				
O	.0104				
P	.0104				
Q	.0104				
R	.0103				

POST TEST

Weight 0.228 gms.

Thickness		Width		Length	
A-B	.0123	A-C	.900	A-P	1.530
B-C	.0122	D-F	.905	B-Q	1.480
C		G-I	.900	C-R	1.520
D-E	.0122	J-L	.880		
E-F	.0123	M-O	.875		
F		P-R	.870		
G-H	.0124				
H-I	.0124				
I					
J-K	.0123				
K-L	.0122				
L					
M-N	.0124				
N-O	.0123				
O					
P-Q	.0122				
Q-R	.0122				
R					

Measurements of Coupon Ser. No. 74, Test No. TFL-5.b-032

PRE TEST

Weight 0.268 gms.

Thickness		Width		Length	
A	.011	A-C	.990	A-P	1.591
B	.011	D-F	.990	B-Q	1.595
C	.011	G-I	.990	C-R	1.597
D	.011	J-L	.990		
E	.011	M-O	.992		
F	.011	P-R	.989		
G	.011				
H	.011				
I	.011				
J	.011				
K	.011				
L	.011				
M	.011				
N	.011				
O	.011				
P	.011				
Q	.011				
R	.011				

POST TEST

Weight 0.207 gms.

Thickness		Width		Length	
A-B	.0126	A-C	.918	A-P	1.519
B-C	.0127	D-F	.920	B-Q	1.531
C		G-I	.905	C-R	1.530
D-E	.0129	J-L	.919		
E-F	.0127	M-O	.911		
F		P-R	.871		
G-H	.0126				
H-I	.0127				
I					
J-L	.0128				
K-L	.0128				
L					
M-N	.0126				
N-O	.0127				
O					
P-Q	.0128				
Q-R	.0127				
R					

Measurements of Coupon Ser. No. 73, Test No. TFL-5.b-033

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

PRE TEST

Weight 0.287 gms.

Thickness		Width		Length	
A	.0106	A-C	.9990	A-P	1.5950
B	.0107	D-F	.9990	B-Q	1.5850
C	.0106	G-I	.9995	C-R	1.5850
D	.0105	J-L	.9990		
E	.0106	M-O	.9992		
F	.0106	P-R	.9995		
G	.0105				
H	.0106				
I	.0107				
J	.0106				
K	.0107				
L	.0107				
M	.0106				
N	.0107				
O	.0107				
P	.0105				
Q	.0107				
R	.0107				

POST TEST

Weight 0.209 gms.

Thickness		Width		Length	
A-B	.0123	A-C	.830	A-P	1.481
B-C	.0123	D-F	.868	B-Q	1.470
C		G-I	.880	C-R	1.480
D-E	.0123	J-L	.870		
E-F	.0126	M-O	.890		
F		P-R	.860		
G-H	.0125				
H-I	.0126				
I					
J-K	.0125				
K-L	.0126				
L					
M-N	.0125				
N-O	.0125				
O					
P-Q	.0123				
Q-R	.0123				
R					

Measurements of Coupon Ser. No. 77, Test No. TFL-5.b-035

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

PRE TEST

Weight 0.302 gms.

Thickness		Width		Length	
A	.0108	A-C	.996	A-P	1.587
B	.0108	D-F	.998	B-Q	1.591
C	.0107	G-I	.999	C-R	1.590
D	.0107	J-L	.999		
E	.0106	M-O	.999		
F	.0106	P-R	.998		
G	.0107				
H	.0106				
I	.0106				
J	.0107				
K	.0107				
L	.0106				
M	.0106				
N	.0107				
O	.0106				
P	.0106				
Q	.0106				
R	.0107				

POST TEST

Weight 0.220 gms.

Thickness		Width		Length	
A-B	.0125	A-C	.892	A-P	1.510
B-C	.0123	D-F	.900	B-Q	1.510
C		G-I	.850	C-R	1.500
D-E	.0124	J-L	.879		
E-F	.0123	M-O	.871		
F		P-R	.860		
G-H	.0124				
H-I	.0124				
I					
J-K	.0124				
K-L	.0123				
L					
M-N	.0124				
N-O	.0124				
O					
P-Q	.0124				
Q-R	.0124				
R					

Measurements of Coupon Ser. No. 70, Test No. TFL-5.b-036

PRE TEST

Weight 0.310 gms.

Thickness		Width		Length	
A	.0106	A-C	1.000	A-P	1.602
B	.0106	D-F	0.999	B-Q	1.600
C	.0107	G-I	1.000	C-R	1.600
D	.0106	J-L	0.999		
E	.0106	M-O	0.998		
F	.0107	P-R	0.998		
G	.0106				
H	.0107				
I	.0107				
J	.0107				
K	.0107				
L	.0107				
M	.0107				
N	.0106				
O	.0106				
P	.0107				
Q	.0107				
R	.0108				

POST TEST

Weight 0.193 gms.

Thickness		Width		Length	
A-B	.0125	A-C	.819	A-P	1.460
B-C	.0125	D-F	.800	B-Q	1.340
C		G-I	.800	C-R	1.449
D-E	.0125	J-L	.780		
E-F	.0126	M-O	.806		
F		P-R	.792		
G-H	.0125				
H-I	.0125				
I					
J-K	.0125				
K-L	.0124				
L					
M-N	.0124				
N-O	.0123				
O					
P-Q	.0123				
Q-R	.0123				
R					

Measurements of Coupon Ser. No. 76, Test No. TFL-5.b-037